Electricity Demand

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Outline

• What is electricity demand?
• Characteristics of electricity demand
• Technology improvement and metering
• Profiling
• Demand side management (DSM)
Pattern of demand

• High volatility
• Yearly, monthly, daily seasonality
• System must be kept balanced all the time – so supply must follow demand (in the short and long term as well)
• Appearance of ‘prosumers’ could change the picture profoundly
Which one is an electricity load curve?
Typical load curves - year

Load, available capacity and peak usage, 2013, Hungary

Legend: \(\cdots\cdots\) load, \(\cdots\cdots\) available capacity, \(\cdots\cdots\) daily peak usage of capacity,

Source: Tihanyi presentation on REKK course, 2014, Mavir
Typical load curves - month

Load, available capacity, April 2014, Hungary

Legend: ---- load, --- available capacity, --- daily peak usage of capacity,

Source: Tihanyi presentation on REKK course 2014, Mavir
Typical load curves - day

Load, available capacity, 2014 Daily load curve, Hungary

Source: Tihanyi presentation on REKK course 2014, Mavir

Legend: load, available primary down, available primary up,
Drivers of demand 1

Source: SmartAuctus Project (2009)
Drivers of demand 2 – Example of UK - Olympics game opening

Source: Tihany presentation on REKK course 2014, Mavir
Structured view of demand

Daily load curve: demand variation within day

Load duration curve: demand pattern over the 8760 hours of a year
Impacts of changing demand – base hour

Electricity Demand
Hour: 5.30 in the morning

Supply curve

P

P base

Q

(Wind) nuclear coal gas oil biomass

Q_b
Impacts of changing demand – peak hour

Electricity Demand Hour: 6.30 in the morning

Supply curve

(P) peak

(P) base

(Wind) nuclear coal gas oil biomass

Q
Drivers of demand

Electricity is not consumed directly by individuals: Demand for electricity is the result of demand for services provided by energy-using appliances.

Main drivers

- prices and availability of substitutes
- prices of appliances (complements)
- changes in economic structure
- technology
- changes in energy policy
- weather
- income
- and the price of electricity

These usually condensed to 3 drivers:

- Income elasticity
- Price elasticity
- AEEI: Autonomous Energy Efficiency Indicators
Income elasticity of electricity demand

Shows the average percentage change of the demanded quantity that occurs in response to one percent rise in income

– If household income increases, how would it affect electricity demand?
– Do countries with higher GDP consume more? By how much?

Possible ways for measurement:
– Relationship between GDP and total electricity consumption

Results vary but among the two there is no significant difference: 0.2-1.1
– Important point: 0 and 1 – what are their meaning?
GDP - electricity consumption

Source: Hungarian Energy Strategy background study REKK
Price elasticity of electricity demand

**Definition:** Percentage change in electricity demand if price changes by one percentage.

**Rather inelastic.**

**Reasons:**

- Substitutability is limited: heating, hot water – yes, in the rest almost none
- Non-observed prices: consumption and billing is not really connected (PROFILING!)
- Derived demand of appliances, therefore it is not as price sensitive as it would be in case of a good with a direct demand
Price elasticity of electricity demand

Magnitude of demand response depends on the time available for reaction:
- Short term: Changing the use of current appliances
  e.g. turning down the air conditioner
- Long term: Changing the appliances and the time
  e.g. buying new appliances and changing the old ones to more energy efficient ones
Price sensitivity of households

Figure 8: Average monthly saving from switching from the incumbent’s standard offer to the lowest-priced offer on the market – capital cities – December 2012 (euros/month)

Source: Acer 2014
Price and income elasticity estimates

Source: Carol Dahl 2011
Characteristics of price elasticity

• There is price response: demand for electricity is not vertical, although inelastic – but this impact is weak
• Elasticity is different for price increase and price decrease
• Different in long and short run
• Different for residential and non-residential users
  – Non residential: bigger industrial consumers are more aware of the problem – as their contractual price depends on their consumed quantity and shape!
  – So they are more interested in keeping their load forecast!
Households: artificial inelasticity!

Fixed retail price for households:

– Although as we have seen, customers (mainly households) would hardly respond, since they do not face short term price changes at the end they do not respond to it

– Fixed retail price:
  • Results in no customer reaction to short and mid term changes in prices
  • Results in cross-subsidization between peak consumers and off-peak consumers
  • Results in a vertical demand curve on the wholesale market – demand is artificially inelastic
  • Lagged billing cycles makes the problem worse

– In sum: for households - price elasticity is almost zero, income elasticity what matters!
Metering technology
Traditional meters

Cumulative recording
  – Display in kWh
  – no exact measures of current consumption
Manual (visual) reading
Monthly bills based on:
  – self-reporting
  – consumption estimates (payment smoothing possible)
Infrequent reading by utility
1-2 times a year
yearly adjustment bills
More advanced meters

Multiple registers for recording consumption on different times of the day
  – or multiple meters
Retrofitting existing electromechanical meters
  – Prepayment attachment
  – Real-time display attachment
  – Communications attachment
Electronic versions of the above
Smart metering

Two-way communication capability
Real time display of prices
Automated meter reading
  – via various communication networks
Automated meter management
  – remote changes in contracted power or price schemes
  – remote disconnection/reconnection

Smart metering ≠ smart grids
Smart meetering in the EU

Figure iii Household consumers with electricity smart meters (%) – 2016

Profiling
Decentralised dispatch and system security

Transmission System Operator (TSO)
Responsible for system security and balance
Day-ahead aggregate schedule
Operation of ancillary services and balancing market

Self-scheduling

Balance Group 1
Balance Group 2
Balance Group 3

E / I
G
G
C
C
C

In case of fully bilateral trading, price transparency is lacking!!
Profiling 1

- Balance group leaders: 15-minute day-ahead schedule to the system operator.
- Settlement of balancing energy and network losses: metered data – schedule.
- There are not everywhere appropriate meters to do that – solution:
  - consumer profiles.
- Profile ≠ metered consumption.
  - Volume difference: estimated and real yearly consumption.
  - Formal difference: statistical and real load curve.
- Predetermined consumption curve and schedule for different consumer groups based on statistical method.
The task of profile setting is given to the distribution companies in their license

Sample:
- Interval meters are setup at 2000 consumers
- 10 million metered data was analysed by an independent research institute

First results based only on consumption data:
- 5 different consumer groups

Next: consumption data is complemented with further type of data from individual questionnaire
- Finally 4 different country-wide consumption group

Additional profiles for public lighting and direct-load-control
(this is different for each distribution company)

For each group 9 curves defined:
- 3 (workday, Saturday, holiday)
- 3 (Winter, Summer, transitional)
Examples of Profiles - Hungary

Weekdays                      Saturday                            Sunday

Group 1: 16.7 %
Group 2: 16.2 %
Group 3: 34.6 %
Group 4: 32.6 %
Demand Side Management
Solutions

Traditional power system models:
– Vertically integrated utilities:
  • Take demand as given – satisfy it at any cost
  • No info on real cost of balancing
  • No interest in increasing price responsiveness of consumers

More competitive models, separation of roles:
• Cost of balancing is revealed – it gives information at what cost balancing takes place – more incentive to demand side participation
• First steps: multiple meters, but more sophisticated systems to come
Demand-side Management Definition

Demand-side management (DSM) programs aim to encourage consumers to modify their level and pattern of electricity usage.

This includes:
- planning,
- implementing, and
- monitoring activities of electric utilities.

Two froms:
- Energy efficiency
- Demand response

Source: EIA
Energy Efficiency

- Permanent change (base load DR)
- It results in demand reduction in all hours
- Affects the energy balance
- Usually through the change to more efficient equipments

Demand response

- Short-term, discrete changes to demand profile
- Might result in increase in consumption (off-peak periods)
- Affects the power balance
Types of Demand Response

• Incentive-based
  – Direct load control
  – Interruptible/curtailable rates
  – Emergency Demand Response
  – Capacity Market Programs
  – Demand Bidding/Buyback Programs

• Price-based
  – Time-of-Use Rates
  – Real-Time Pricing
  – Critical Peak Pricing
The simplest form are varying tariffs according to time of use.
Off-peak periods are usually weekday nights and weekends while peak periods are the weekday mornings and afternoons. The actual hours of peak periods vary from program to program, just like the ratio of peak and off-peak tariffs.

Examples: Serbia, Hungary, Czech Republic:
- Existence of normal and night tariffs

Serbian household tariff:
- Two-rates:
  - On peak: 7:00 – 23:00
  - Off-peak: rest
- HT:LT = 3:1
- Requires two meters, but with radio control could be flexibly applied for demand management as well
Estimates on future of DR programs in EU 27, 2050. TWh

Big potential in energy savings, but 'rebound' effect also exists
Source: ECF, Roadmap 2050
Further challenges

• Appearance of ‘prosumers’ also change the picture:
  • Some of the consumers (households and SMEs) cover their demand by own production – further increases volatility and creates hurdles to balance group managers – lower predictability

• Diffusion of electric cars and improving efficiency of batteries (and other reserve technologies) further changes demand patterns

• These changes questions the traditional roles and models for DSO financing – need to reduce weight on the energy component in the future
THANK YOU FOR YOUR ATTENTION!

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